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ABSTRACT

This paper proposes a theoretical foundation for the field of educational technology based on cognitive learning theory. This proposition is based on consideration of issues which suggest that psychological theory is more central to educational technology than systems theory or theories of management, and that cognitive theories are more fundamental than theories of instruction. Schon's concept of professional expertise is discussed, and it is argued that instructional design would emphasize acquisition of a well-rounded knowledge base over techniques, with the designer able to make students reason from first principles rather than simply helping them find which techniques to apply. Although it is noted that there is likely to be opposition in the field of educational technology to a more theoretical approach, it is suggested that this approach will assist in professionalizing the field and move the field of educational technology beyond the structures and institutions of traditional education. (37 references) (EW)

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Introduction.

A major criticism of the field of Educational Technology has been that it has tried to be all things to all people. Referring to definitions of the field (Ely, 1972; Silber, 1970; Rowntree, 1974; AECT, 1977), Nunan (1983) points out that Educational Technology appears to claim a role in all aspects of Education, differing only from the other subfields by being more systematic in what it does. This, added to the tendency to equate the practical application of knowledge -- our stock in trade -- with a rejection of theory, has led to a situation where the field is being pulled in many directions at once and lacks an anchor point to give it stability. It is therefore necessary to identify what the theoretical foundations of the field are and to propose how the field can build itself up from a solid foundation in theory. The recent book by Gagne (1987) takes an important step in this direction in that its chapters concentrate for the most part on learning and instruction. This paper attempts to go further in this direction and to strip the field down to its essentials.

The purpose of this paper is not to suggest another definition for the field. Rather it seeks to examine an extant one in such a way as to make the field's foundations clearer. The definition is not new to Educational Technologists. It is based on Galbraith's (1967) definition of technology as "the systematic application of scientific and other organized knowledge to practical tasks." If we substitute "educational tasks" for "tasks" and "knowledge about Education" for "knowledge", then we have a definition of the field that has been accepted by those working in it for years.

It is important that this definition implies that Educational Technology is a process. What is more, it is a decision-making process that Simon (1981) and Glaser (1976, 1985) have called "design". It is certainly not a theory, as AECT (1977) has claimed if for no other reason than the fact that processes, while guided by theory and in some cases even producing theory, cannot themselves be theory. (Whether Educational Technology is a discipline and a field, which AECT also claimed, is debatable but beyond the scope of this discussion.)

The definition points to how theory might relate to Educational Technology. Indeed, theory has the potential for fitting into each of the three parts of the definition. "Systematic application" is not itself theory and instructional development is atheoretical. Yet it is conceivable that a theory might be developed that explains and predicts how following different development procedures could lead to different learning outcomes. Gerlach (1984), for one, has stated that research that might lead to such a theory is urgently needed. "Practical educational tasks" are not theory either. Yet some aspects of curriculum theory, aligned closely with Sociology and Political Science, do explain and predict

how the practical tasks of Education are identified in particular social and political systems. Yet in neither of these cases does theory exist that Educational Technology can point to as its own.

It is in the "scientific and other organized knowledge about Education" that the theory that drives Educational Technology is to be found. The examination of the definition of the field, which is the purpose of this paper, must therefore begin with a clarification of what the theory that contains this knowledge is, for it is here that the foundations of the field must lie. As we shall see, once the theoretical foundation of the field has been acknowledged, it will be necessary to rethink certain aspects of how that knowledge is applied, and even the scope and nature of the practical tasks that Educational Technology is best fitted to address. What will result is a narrower conception of the field, but one that is more manageable, more viable, more respectable and more unique.

Theoretical Foundation.

It is the contention of this paper that the main theoretical foundation for the field is cognitive learning theory. In order to support this contention, convincing arguments must be presented: that psychological theory is more central to Educational Technology than, say, system theory or theories of management; that cognitive theories are more useful than behavioral theories; and that theories of learning are more fundamental than theories of instruction. The case for each of these is progressively harder to make. But it can be made as we shall see in the following sections.

The need for Psychological theory.

The "bottom line" of Education is learning, and learning is a psychological process. This is so obvious that it seems that there is nothing more to say. Yet there are those who argue that this is not the case, and that theories of management, or system theory, are really what Educational Technology should be founded on (see Heinich, 1984). Doubtless such theories are important and relevant. But they are not fundamental. For example, a major purpose of management theories, applied to education, is to make educational institutions more efficient, which is fine and necessary. But the need for efficiency in educational institutions is determined in turn by the need to help students learn. Regardless of how far from students one's concerns for institutional efficiency are, the students are always there, and the results of any action one takes can always be traced when all is said and done to a student somewhere attempting to learn something.

A similar argument can be made for system theory. This mathematical theory of the behavior of complex organisms (Bertalanffy, 1968) has been thoroughly misunderstood, misinterpreted and abused by a great many educational technologists. It is concerned with how complexity might be described and controlled, and permits us to consider systems as wholes. It is only secondarily concerned with systematicity in decision-making, or

design. And even then, we have grossly oversimplified the basic theory. In fact, the majority of the embodiments of "the Systems Approach" have nothing to do with system theory at all and are nothing more than rather fatuous and unsuccessful attempts on the part of some instructional developers to make their work appear to be theoretically rigorous (which it is not). Davies (1981), Andrews and Goodson (1980) and others have, to their credit, clearly spelled out the difference between being systemic and being systematic. With the emphasis on being systematic rather than systemic, instructional design and development "models" often appear as no more than lists of steps which, if performed in the correct order, might, with luck, lead to instruction that is reasonably effective. Such a conception of decision-making is so utterly devoid of theory that to call it an application of system theory is quite ridiculous.

The exception proves the rule, of course. In those cases where educators have understood system theory, it has proven to be the powerful tool that it has always had the potential of being. I will give three examples. The first is the work of Heinich (1970, 1984) who has been very successful in drawing to our attention the great complexity of educational and instructional systems and how the introduction of technology into the educational milieu makes these systems even more complex. Yet Heinich's application of system theory to education is for the purpose of educational and instructional management, which is to say it is at least one step removed from the student who is trying to learn something. The "paradigm" for instructional management presented in the 1970 monograph describes various ways in which technology and teachers might fit together in workable ways in order to instruct. But, wisely, it does not say anything about the nature of the instruction that might be designed and delivered. (I might add that the chapter on learning theory is the least successful in this important book).

The second example is to be found in the admittedly difficult writings of Pask (1975, 1984). Pask's "Conversation Theory" is something of an offshoot of system theory in that it is largely concerned with mechanisms of feedback and other cybernetic constructs that are relevant to the interaction of an organism with its environment. Pasks' theory is nonetheless concerned with education and provides an ample framework within which to explain how the learner, as a system, assimilates new knowledge and accomodates to it.

The third example is, perhaps suprisingly, the work of Piaget (1967). While Piaget is not primarily thought of as a systems theorist, there are nonetheless many echos of system theory in his work. (Like Von Bertalanffy, he was a biologist by training, and they certainly knew each other). The notions of assimilation and accomodation, which are fundamental to Piagetian theory, are more than coincidentally similar to catabolic and anabolic processes in living organisms, explained by system theory. Equilibrium and homeostasis are to all intents and purposes identical constructs.

And Piaget's (1970) book Structuralism, little read by educators, likewise contains many ideas that are traceable to system theory.

Something quite fascinating appears when you consider these examples. First, as we have seen, Heinich does not apply system theory directly to instructional decision-making. We therefore cannot consider it to be fundamental. Second, in the work of Pask and Piaget, the application of system theory to education takes place in a psychological context. Pask and Piaget are not concerned with being systematic while doing instructional design, nor even with instructional strategies and methods, but with the psychological implications of looking at the learner as a complex cognitive "organism". Thus, we might easily conclude that when system theory is properly applied to education, it is either only indirectly concerned with instruction (as with instructional management, for example), or else it is concerned with psychological issues. Only in the latter case is it directly concerned with the learner.

The need for a cognitive emphasis.

Doubtless, those psychological theories that have been most successful in guiding instructional design have been behavioral. The work of Skinner (1954), for example, produced a descriptive theory of learning called "operant conditioning", a prescriptive theory of instruction derived directly from operant conditioning, techniques for delivering instruction such as teaching machines and programmed instruction, and even a philosophical frame of reference (Skinner, 1971) which stressed the necessity for man to give up freedom and dignity in order to survive. The whole forms a package whose completeness has not subsequently been matched. Likewise, Gropper's (1983) behaviorally-based instructional theory is the most thorough of all of those presented in Reigeluth's (1983) compendium.

However complete, thorough and practical behavioral theories of learning and instruction might be, they are nonetheless based on an inadequate account of how people learn. (As we shall see, the choice we have to make in our field is whether we do what we do well but limit our effectiveness to only a few aspects of instruction, or whether we try to broaden the applicability of what we do at the risk of doing it less well for the moment. Obviously, I have opted for the latter). The arguments for a cognitive approach to learning and instruction are many, convincing and largely known. They range from Koestler's (1967) contention that there are emergent properties of human thinking that behaviorism cannot explain, to Neisser's (1976) account of the importance of schemata in determining what is learned, to Wittrock's (1979) description of learning as a generative process. Shuell (1986) has provided a thorough account of the major components of cognitive learning theories.

Our field remains wedded to its behavioral roots. There are two reasons for this. First, historically, the field found its feet during the heyday of Behaviorism in the early 'fifties, when

programmed instruction was "all the rage". Had the field grown up in the 'twenties and 'thirties, alongside Gestalt psychology, for example, it might have looked very different today. Second, instructional design as we have come to know it can only flourish within a behavioral context. This is because any instruction whose design is separated in time from its implementation can only ever present information as stimuli for students to react to. Students cannot modify the program of instruction (the stimuli) to any extent without it falling to pieces. This is why instruction produced through the usual design process is most successful in those situations where students are largely passive and are learning lower-level skills (in the Gagnean sense), that is to say in training settings.

When one acknowledges that students are capable of thinking for themselves, and that learning occurs when someone acts upon information rather than simply reacting to it, two things become clear. The first is that instruction has to be sufficiently flexible to deal with all of the things that happen when cognitively active learners engage in it and that could not have been anticipated by instructional designers. This requires that some, even if not all of the instructional decisions must be made in interaction with students once instruction has begun. This is normally taken care of when a good teacher delivers the instruction (Nunan, 1983). The second thing that becomes clear is that most current "models" of instructional design are largely inappropriate in a cognitive context. This is because they require that all instructional decisions be made, and tested, before instruction is implemented, and that they leave no room for adaptation once instruction has begun. There are, of course, exceptions. The work of Greeno (1980), Resnick (1976) and others has given rise to a variety of cognitive instructional design procedures. But once again, these have emerged directly from psychological theory and research and not from educational technology.

It is, therefore, only when instructional decision-making occurs during instruction, either through the agency of a good teacher or of an intelligent tutoring system, that it is possible for instruction to follow the principles of cognitive theories of learning and instruction. This implies a new role for instructional designers (Winn, 1987). Rather than selecting instructional methods given what the outcomes of instruction are to be and the conditions under which it is to occur, designers will increasingly be concerned with studying how such decisions are made and with building instructional systems that are capable of making them.

Theories of learning and of instruction.

The final stage of our argument requires us to look at descriptive theories of learning and prescriptive theories of instruction. As Reigeluth (1983) has pointed out, learning theories are not necessarily descriptive, nor are instructional theories necessarily prescriptive. But for our purpose, it is sufficient to

distinguish between descriptive theories that describe what happens when someone learns something and prescriptive theories that tell us what to do in order to get someone to learn something. The argument is that descriptive theories are more fundamental to educational technology than prescriptive theories in contrast to what is currently believed to be the case.

The first point to make is that descriptive theory precedes prescriptive theory. While this does not imply that descriptive theories can necessarily be simply restated in prescriptive form, as Landa (1983) has pointed out, it does suggest that we have to be able to describe something before we can determine what it is that we have to do in order to bring that something about. Behavioral theories of learning and instruction are perfect examples of this. The work of Pavlov, Skinner and the other behaviorists was originally descriptive. It described and explained what happened when a stimulus was presented to an organism under various conditions. Prescriptive theory was only possible once this explanatory theory had been well developed.

The second point is that one of the reasons behavioral theories of instruction are, within their limitations, so complete is that they are built from what is known about the conditions that are necessary for learning to take place. As Clark (1983), among others, has pointed out, theories of instruction fall short of satisfactory if they merely address the sufficient, as opposed to the necessary conditions of learning. Thus, while we can demonstrate that giving a rat an electric shock may be sufficient to extinguish a learned behavior, so may a whole host of other negative reinforcers. The key to this form of extinction is therefore not the realization that an electric shock extinguishes learning but the more general theoretical principle of negative reinforcement. This is relatively clear in the case of behavioral theories as these are well developed and complete.

The same cannot be said for cognitive theories. Because they have to account for far more complex phenomena than behavioral theories, and because research aimed at developing them began more recently than behavioral research, they are far less developed and complete. This has had two results. The first is that prescriptive cognitive theories of instruction, such as they are, are incomplete and therefore less reliable than they will be. Second, instructional designers have been tempted to derive principles from the bits and pieces of cognitive research that have been completed, and have therefore relied, often unwittingly, on what is known about the sufficient, rather than necessary conditions of learning. This not to say that there is no descriptive cognitive learning theory. The work of Neisser (1976), of Rumelhart and Norman (1981) and many others belies that assumption. The problem stems from the less complete state of cognitive theory and from the fact that instructional designers by and large do not know the difference between sufficient and necessary conditions. The prescriptions for action in cognitive theory simply do not exist in sufficiently

reliable form for them to be useable.

What this means is that descriptive theories of learning are, at present, more reliable than prescriptive theories of instruction within the cognitive framework. It is therefore best if instructional designers work with descriptive theory rather than with incomplete and sometimes misleading prescriptive principles. With a knowledge of how people learn, the designer can act as each set of circumstances permits and at the same time adapt theory to particular needs rather than blindly following "cookbook" prescriptions for instructional design.

Theory-based instructional design.

Stewart (1985) has criticized the instruction students in educational technology programs receive for teaching techniques rather than principles. Clark (1978) has, likewise, levelled criticisms at our graduate programs from not emphasizing research and inquiry. Both of these criticisms are justified. If students are taught that instructional design is a simple process that leads to effective instruction provided that the instructions in each box in a flowchart are carried out and that the selection of instructional strategies can be achieved by looking them up in a table, then they have been taught techniques that are not founded in theory. The instructional designer trained in this manner can "do" instructional design up to a point, provided that nothing unforeseen occurs. But that designer cannot reason about what he or she is doing and therefore has great difficulty transferring the design skills learned in the design course to any "real-world" setting. The designer trained in this way is at a particular disadvantage when a problem shows itself during the field testing of instruction whose solution has not been directly addressed in the design course.

When one looks at the way in which an expert in any field functions, one finds that they do not simply use techniques for getting the job done. Schon (1983, 1987) has characterized professional expertise by the ability to carry out what he calls "reflection in action". Reflection in action is nothing more nor less than the ability to reason about problems from first principles, to conduct, if you will, small spontaneous experiments that are guided by a general theoretical framework but aimed at particular and usually unforeseen problems. Schon documents his two books with examples from a number of professions. In each case, we see expert professionals achieving an impressive blending of theory with practice through what is in effect spontaneous research. If Educational Technology is indeed a profession, this is a standard that it should emulate.

What might instructional design look like given Schon's conception of things? To begin with, the emphasis in design training would be less on techniques and more on the acquisition of a well-founded knowledge base. It would also be accompanied by an extensive "reflective practicum" in which the student would be apprenticed to an expert designer who in addition to being good at design would

also be good at helping the student reflect in action. In other words, the designer would have the ability to make students reason from first principles rather than simply helping them find which techniques to apply.

Once beyond training, the instructional designer would refer to knowledge about how people learn in order to draw guidance in instructional decision-making. The advantage of this would be that variations in the context in which instruction is to be designed would cease to be problematic. The designer would be able to function at a level of generality sufficient to transcend the specific nature of each instructional setting. Theory, remember, is by definition sufficiently general and robust to be valid in all situations. It has the property of being able to predict what will occur even if the circumstances are entirely new.

A final comment. It is quite likely that before long computer-based expert systems will be doing instructional design (Merrill, 1987). But it will be a long time before computers can reflect in action. This means that computer-based instructional design systems will operate at the "technique" level and will design instruction that continues to be behaviorally oriented, predetermined and incapable of all but the crudest of adaptations to changing conditions during its implementation. Instructional designers will still be needed to bring their knowledge of learning theory to instructional problems and to reason from first principles, which is something that computers will not be able to do for a long time.

Conclusion

We have argued that the foundation of the field of Educational Technology is to be found in cognitive theories of learning and we have seen how this might change the way in which instructional designers ply their trade. By way of conclusion we shall look at an important implication of this for the practice of the field.

Doubtless the ideas presented so far will not go down well with those in our field with a more "practical" bent. The history of our Association reveals that there has always been opposition within the field to research and theory that has at times bordered on hostility. This is to be expected. Educational practitioners are handicapped by all manner of constraints that make it difficult for them to operate from first principles. They have little time for decision-making themselves and there are few incentives for them to be innovative. They have in all likelihood been trained in the first place in a program that emphasizes techniques rather than theory and principles. And their orientation is probably behavioral. They are therefore probably not only unwilling but also unable to reflect in action in order to make instructional decisions.

If for no other reasons than these, it can be concluded that if Educational Technology is to survive, develop and thrive, then it must do so outside the traditional structures and institutions of Education. This is an argument that Heinich (1984) has made already, and the reader is referred to his insightful and prevocative

article. It is worth noting that, in the estimation of many, some of the most successful applications of Educational Technology have indeed occurred outside these traditional structures. (Britain's Open University comes immediately to mind). It is also worthy of note that these successes have occurred without heavy reliance on the "techniques" of instructional design that are taught in most of our graduate programs.

The other side of the coin is that traditional institutions are doing just fine and have no need for Educational Technology (Nunan, 1983). This should not be taken as a condemnation of the field but as further evidence that it is more likely to succeed elsewhere. Training and any situation where the student interacts directly with instruction without the mediation of a teacher are examples of situations in which instructional design has an important role to play.

We began with the idea that the field and the Association are trying to go in all directions at once and are, as a consequence, not going anywhere at all. It is hoped that the arguments put forward above will at least be considered by Educational Technologists and that, founded on cognitive theories of learning, the field can advance to the status of a true profession whose members eschew techniques in favor of reasoning from first principles. If the mastery of this approach to the discipline can be demonstrated, it is quite likely that we will be invited to contribute in a major fashion to the reforms of American education that are bound to occur within the next few years.

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